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The modifiable and non-modifiable risk factors of hypertension in the adult population of Kelantan: Structural equation modeling approach

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ABSTRACT

Introduction: Hypertension is a silent disease that can lead to serious complications such as heart failure, acute coronary syndrome, renal failure, and stroke if not treated early. This study is to elucidate a model of modifiable and non-modifiable risk factors for hypertension and this model could give a clearer picture regarding the relation of each risk factor towards hypertension based on the adult population in Kelantan, Malaysia. *Methodology:* Statistical analysis was performed by using AMOS software through Structural Equation Modelling (SEM). Unlike current methods that focus only on identifying direct associations between hypertension diseases but our method introduces the effects of multiple risk factors simultaneously in a single model involving modifiable and non-modifiable risk factors. *Results:* The risk factors listed below are considered to have a direct statistically significant effect on hypertension: age (0.122, p = 0.001), fibrinogen (0.091, p = 0.003), Body mass index (0.138, p = 0.001), Triglycerides (0.069, p = 0.028) and Diabetes status (0.133, p = 0.001). Family history of heart attack had no significant effect on hypertension in this study (0.016, p = 0.608). The final model demonstrated good model fit where GFI, AGFI, NFI, CFI and TLI value are 0.9 and above. *Conclusion:* The SEM analysis aids in a better understanding of hypertension risk factors and a higher level of confidence in controlling hypertensive patients' risk factors.

Keywords: Structural Equation Modelling, Hypertension, Modifiable and Non Modifiable Risk Factors

1. INTRODUCION

The leading cause of death worldwide is non-communicable diseases and one of the main contributors is hypertension. World Health Organisation (WHO) estimated 1.13 billion people have hypertension worldwide and two-third of the hypertensive person is from low and middle-income country (WHO, 2020). Uncontrolled hypertension may lead to serious complications including heart failure, acute coronary syndrome, renal failure and stroke if not treated early. Relationship between cardiovascular events and high blood pressure is correlated and does not depend on other risk factors. The risk of heart failure, myocardial infarction, and stroke increases as blood pressure increases (MOH, 2018).

Hypertension is a silent disease. According to National health and mortality survey 2015, prevalence of hypertension in Malaysia was 30.3% and more than half (17.2%) of the respondent did not know that they had hypertension (MOH, 2015). That is why screening for hypertension to all adult who came for healthcare check-up is very important. The exact aetiology of hypertension remains unclear; however there are several risk factors that are strongly and independently associated with developing hypertension. Age and family history are the non-modifiable risk factors for hypertension. Vascular structural changes occur with ageing, endothelial dysfunction and narrowing of arterial lumen observed in ageing people that can lead to hypertension (Bruno et al., 2017). Family history of hypertension need to be obtained when seeing patient suspected to have cardiovascular disease, it is because individual with both parents who had hypertension had two times risk to get hypertension over the course of adult life (Wang et al., 2008).

Obesity and weight gain are the major modifiable risk factors for hypertension. The severity of hypertension also increases in hypertensive individual who are obese. Obese individual are nearly 14 times likely to have Stage 2 hypertension than non-obese individual (Mahadir et al., 2019). A systematic review by Jeyadi et al., (2018) shows that risk of hypertension is increased continuously with high anthropometric measurement such as waist-to-hip ratio, waist-to high ratio and weight gain. That is why weight reduction is an important management in hypertension especially in obese patient (MOH, 2018). There are positive association between level of blood glucose and hypertension. Diabetic patient had 50% more risk on developing hypertension and severe hypertension was almost two times higher among diabetic people. Apart from glucose level, serum lipid abnormality is also an important risk factor for hypertension. Chance of developing clinical hypertension increase significantly (from 30%-80%) in people with high blood cholesterol compare with normal blood cholesterol level (Mahadir et al., 2019). The possible explanation is that high plasma lipid levels causes low nitric oxide (NO) that contributed to high arterial blood pressure (Pereira et al., 2006).

Non-healthy lifestyle such as physical inactivity and smoking habit are risk factors for hypertension among Malaysian (Lim and Yong, 2019). Sedentary lifestyle causes increase cholesterol level and increase risk for hypertension. Exercise is an important part of hypertension prevention as well as hypertension management. It can reduce systolic and diastolic blood pressure by up to 5-7 mmHg in hypertensive patients (Hegde and Solomon, 2015). Regular moderate to high intensity aerobic exercise also shows significant blood pressure reduction among hypertensive patient (Borjesson et al., 2016). Chronic cigarettes smoker causes chronic arterial stiffness and predispose to hypertension and cardiovascular diseases. Duration of smoking could predispose person to hypertension. Prevalence of hypertension is higher in smokers who smoke more than 30 years compare to shorter duration smoker (Bae et al., 2015).

Relationship of each risk factor contributing to hypertension is still not clearly explained. On this study, we use structural equation modelling (SEM) to elucidate a model of modifiable and non-modifiable risk factors for hypertension. Each variable (modifiable and non-modifiable risk factors) for hypertension can be tested to see whether it correlates with each other and give direct contribution to hypertension. We hope this model could give a clearer picture regarding the relation of each risk factor towards hypertension.

2. METHODOLOGY

Structural Equation Modelling (SEM) is a method or methodology to estimate and evaluate a theoretical system of linear observed or unobserved variables. It uses an input format for checking the validity of the theoretical model on the basis of assumption by using the correlation or covariance matrix between variables. The assumption was that if the theoretical model is accurate and parameters are defined, the population correlation or covariance matrix would be replicable by SEM. Path analysis is the application of latent-variable structural equation modelling. The direct effects are those forces that are not influenced by any other model component. Direct effects are thus depicted as an arrow from an independent exposure variable which leads to a dependent/outcome variable (Bardenheier et al., 2013). The individual indirect effect or collection of indirect effects is a compound of all paths through a specific variable.

In this study was to elucidate the effect of modifiable and non-modifiable risk factor related to hypertension patients in adult population in Kelantan, Malaysia. This association analysis of multiple risk factors provided a conceptual framework for constructing an SEM structure in the following step. The SEM reflected the relationships between all risk factors, their joint action or latent variables, modifiable and non-modifiable risk factor. Table 1 shows the modifiable and non-modifiable hypertension risk factors used in this study.

Table 1 Modifiable and Non-Modifiable Risk Factors of Hypertension

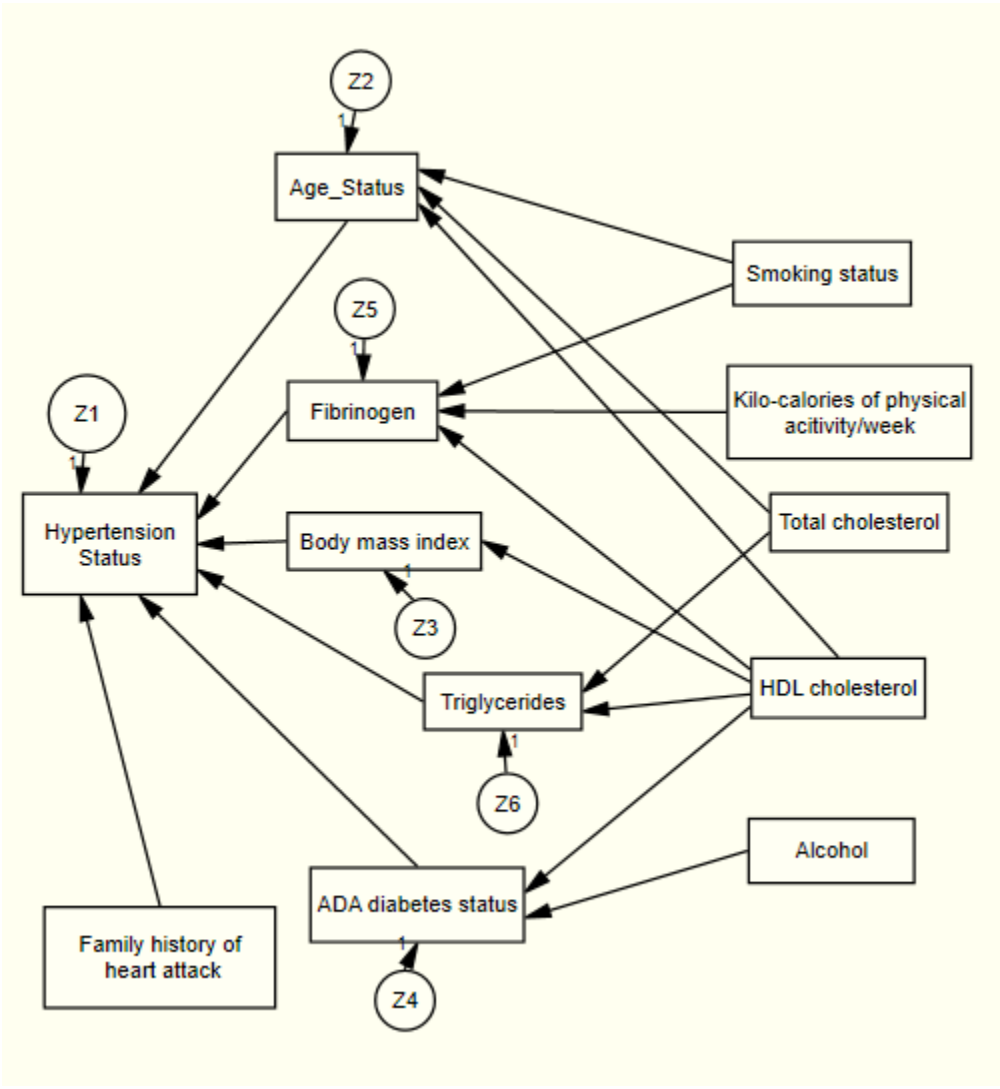| Modifiable Risk Factors	Non-Modifiable Risk Factors
Smoking	Age
Physical activities	Family history of Heart attack
Cholesterol	
HDL Cholesterol	
Alcohol	
Diabetes	
Triglyceride	
BMI	
Fibrinogen	

Figure 1 Structural Equation Modelling of Hypertension using AMOS

We report standardised path coefficients and *p*-values in this analysis. Finally, the best SEM model with the highest goodness-of-fit measure was identified. The fitness of the SEM models is assessed by chi-square checking, root average square approximation error (RMSEA) and the comparative fit index (CFI). The Chi-square test tests the discrepancy between the covariance matrix or correlation observed and the covariance matrix of the model. A good model has an RMSEA of 0.08 or less. Models of 0.08 or more RMSEA suit poorly. The CFI tests the fit of the existing model with respect to models of freedom. A successful model has CFI values above 0.90. The models were designed and estimated using IBM SPSS Amos 20 software. Figure 1 indicates that age, fibrinogen, BMI, triglyceride, diabetes, and family history of heart attacks will affect hypertension disease directly. Smoking status, physical activity/week, total cholesterol, HDL cholesterol and alcohol would also indirectly influence hypertension.

3. RESULT

Figure 2 shows the fully standardised path coefficients of the final model, which had excellent fit. Table 2 shows the coefficients of the effects of variables and *p*-value on hypertension status. The goodness-of-fit statistics of the model are shown in Table 3. Based on Figure 2 and Table 2, the following risk factors deemed to have a direct statistically significant effect on hypertension: age (0.122, p = 0.001), fibrinogen (0.091, p = 0.003), Body mass index (0.138, p = 0.001), Triglycerides (0.069, p = 0.028) and Diabetes status (0.133, p = 0.001). In this study, family history of heart attack factor is not significant effect on hypertention (0.016, p = 0.608).
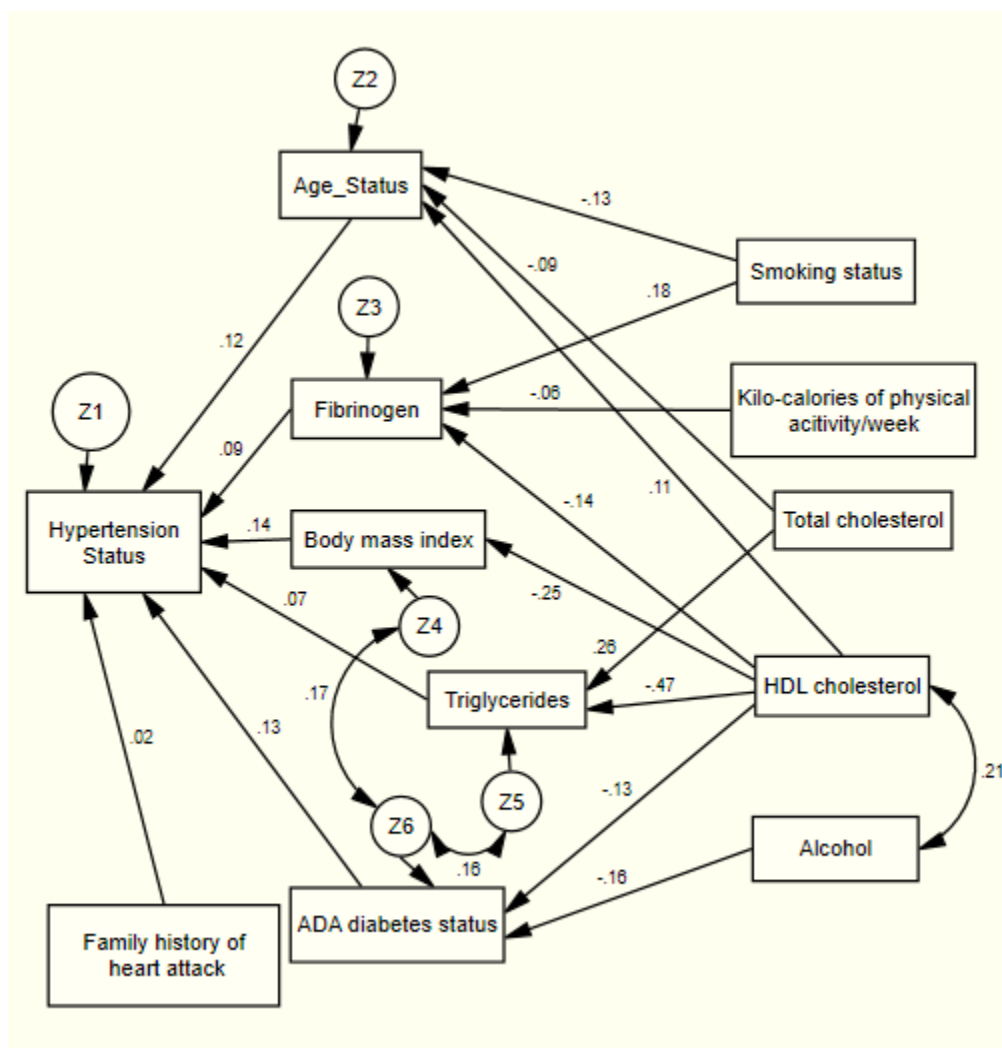

Figure 2 Structural Equations Modelling of Hypertension after Modification Index

The next risk factors have a direct statistically significant effect on age status among hypertention patients: smoking status (-0.134, p = 0.001), total cholesterol (-0.094, p = 0.002) and HDL cholesterol (0.108, p = 0.001). Smoking status (0.183, p = 0.001), Kilo-calories of physical activity/week (-0.065, p = 0.035) and HDL cholesterol (-0.135, p = 0.001) are risk factor to have direct significant effect on fibrinogen among hypertension patients. HDL cholesterol also significant direct effect on body mass index (BMI) among

hypertention patients (-0.250, p = 0.001). Total cholesterol (0.265, p = 0.001) and HDL cholesterol (-0.471, p = 0.001) are risk factor to have direct significant effect on triglycerides among hypertension patients. HDL cholesterol (-0.135, p = 0.001) and alcohol (-0.160, p = 0.001) also significant direct effect on diabetes among hypertention patients.

There are specific indirect effects of smoking status, Kilo-calories of physical activity/week, total cholesterol, HDL cholesterol and alcohol on hypertension patients. Smoking status impact hypertention mediated by age and fibrinogen. Kilo-calories of physical activity/week impact hypertention mediated by fibrinogen. Age and triglyceride are mediating the indirect effects of total cholesterol on hypertension. Age, fibrinogen, BMI, triglyceride and diabetes mediate the indirect effect of HDL cholesterol on hypertension. Besides that, diabetes is mediating the indirect effect of alcohol on hypertension. The covariance between HDL cholesterol and alcohol is estimated to be 1.282. In other words, the covariance between HDL cholesterol and alcohol is significantly different from zero at the 0.001 level (two-tailed).

Table 2 Standardized Path Coefficients and p-value of Variables on Hypertension

Variable	Standardized path coefficients	p-values
Hypertension Status		
Age status	0.122	0.001*
Fibrinogen	0.091	0.003*
Body mass index	0.138	0.001*
Triglycerides	0.069	0.028*
Diabetes status	0.133	0.001*
Family history of heart attack	0.016	0.608
Age status		
Smoking status	-0.134	0.001*
Total cholesterol	-0.094	0.002*
HDL cholesterol	0.108	0.001*
Fibrinogen		
Smoking status	0.183	0.001*
Kilo-calories of physical activity/week	-0.065	0.035*
HDL cholesterol	-0.135	0.001*
Body mass index		
HDL cholesterol	-0.250	0.001*
Triglycerides		
Total cholesterol	0.265	0.001*
HDL cholesterol	-0.471	0.001*
Diabetes status		
HDL cholesterol	-0.135	0.001*
Alcohol	-0.160	0.001*

Table 3 Goodness-of-Fit Statistics of the Model

Goodness-of-fit statistics	Value
Goodness of Fit index (GFI)	0.980
Adjusted Goodness of Fit Index (AGFI)	0.965
Normed fit Index (NFI)	0.900
Comparative Fit index (CFI)	0.900
Tucker Lewis Index (TLI)	0.900
Parsimonious fit (CMIN/df)	2.746
RMSEA	0.042

Based on Table 3, the final model demonstrated good model fit where Goodness of Fit index (GFI) value, Adjusted Goodness of Fit Index (AGFI), Normed fit Index (NFI), Comparative Fit index (CFI), Tucker Lewis Index (TLI) are 0.9 and above. Parsimonious fit is acceptable fit (CMIN/df = 2.746) because less than 5.0. The RMSEA value is 0.042, which is well below the recommended limit of 0.05 or less. Parsimonious fit to degrees of freedom ratios in the range of 3 to 1 indicate an acceptable fit between the hypothetical model and the sample data. Hence, the model shows an overall are acceptable fit.

4. DISCUSSION

In our study, statistical technique called structural equation modelling (SEM) was used to check multiple variables relation with hypertension. The SEM modelling of hypertension using AMOS which is an added SPSS module showed various factors which directly and indirectly influence the high blood pressure in a human. The usage of SEM is useful in linking the hypertension and heart disease of coronary artery in origin (Rodrigues et al., 2020). In addition, the relationship of socioeconomic status, blood pressure, physical activity which analysed direct and indirect effects among South African young women were uniquely done using SEM (Munthali et al., 2018).

Our SEM analysis showed the high blood pressure measurement is directly modifiable by patient's age, their body mass index (BMI), family history of cardiac disease and history of diabetes, high triglyceride and fibrinogen level. From these, it shown age is unmodifiable to the patient compared to other variables. The age as one of the direct influenced of high blood pressure is in agreement to result of age related systolic blood pressure changes by SEM analysis (Justice et al., 2016). The other variables are prone to be controlled by the patient and this should be advised by the medical practitioners to their patients. From this analysis, it shows SEM ability to be used to predict the close relation of the factors which influence hypertension. Interestingly other factors such as serum cholesterol, HDL cholesterol and patient's behaviour such as smoking, alcohol and physical activity were shown as indirect relation to the hypertension. Serum cholesterol and BMI are related to obesity analysis and hypertension by SEM study in Korea (Jeon et al., 2019). Identical finding also noted in the people of China (Ye et al., 2019). This indicate SEM analysis ability to differentiate immediate factors which are more considered crucial than the other variables. This can be strengthened by medical practitioner who is crucial to be controlled suggested by this SEM analysis. Our variables are in addition to other variable which can influence hypertension such as the stiffness of the arteries (Siriopol et al., 2018).

Furthermore, our analysis of factors that cause the hypertension which has the statistically significant finding was non-modifiable such as age with modifiable variables consisted of fibrinogen, body mass index (BMI), triglycerides and diabetes mellitus. These factors should be noted by the medical practitioners in controlling the blood pressure of their patients since it may directly be controlling their further damaging target organs. Interestingly the heart problems in the family have not significantly affected the hypertension. However, this history of heart problems could further have added to their managing information. The history of heart problem could be explored more to understand how the heart become diseased in the immediate relatives.

In addition, further analysis showed smoking, total cholesterol, HDL cholesterol and physical activities were also noted to have significant influenceand relation to the age of the hypertensive patient. The fibrinogen levels of the hypertensive patient are influenced by smoking, physical activities and HDL cholesterol level. The BMI level is influenced by HDL cholesterol in the hypertensive patient and cholesterol level such as total cholesterol and HDL cholesterol will influenced the triglycerides level of the hypertensive patients.

5. CONCLUSION

The SEM analysis helps more in the understanding the hypertension risk factors with increased confidence in controlling the risk factors of the hypertensive patients. Our result helps to differentiate between direct and indirect of factors of hypertension by using SEM analysis together with further understanding how the risk factors influencing each other's.

Author Contributions

Mohamad Arif Awang Nawi: Contributed in the drafting of the manuscript, conception and design of the study, analysis, interpretation of data and final approval.

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